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Right Request 2 pages, Statement 8 pages, Attachment 1 page

[54] Description of invention: Industrial production method of cold-cured pellet used directly for iron and steel smelting

[57] Abstract

This invention is for constant industrial production of cold-cured pellet for steel and iron making. It belongs to iron and steel making field.

This invention uses iron concentrate, non-coking coal and cement clinker as raw materials to produce continuously cold-cured pellets with high thermal strength and used directly for iron and steel smelting at the cost lower than sintered ore. The hot strength can be considerably improved.

The "minisized blast furnace" structure of the cold-cured pellets is firmer. With this invention, we

can increase the reliability of direct steel-making technology, improve the operation of blast furnace, and replace coke with non-coking coal in reaction inside the furnace. The coal-coke replacement rate is >1, so that the iron smelting coke ratio can be considerably reduced and productivity improved.

The cold-cured pellet of this invention can be used in cupola directly for iron making.

(BJ) # 1456

Right Request

1. A kind of industrial production of cold-cured pellet for direct iron and steel making, which is featured as follows:

1) Range of components of the cold-cured pellets:

Iron concentrate: 64-77% (weight)	granularity: -200 mesh	accounting for 65%
Non-coking coal: 13-24% (weight)	granularity: 0.3mm or below	accounting for 95%
Cement clinker: 10-18% (weight)	granularity: 12μm or below	accounting for 90%

The summation of the above-mentioned components is 100% (weight).

2) The pellet contains 11-20% fixed carbon (weight).

3) When the above-mentioned components are mixed, 5-10% water is added to plate or column pelletizer for production of 6-16mm raw pellets with smooth surface. The pellets, when moist, are constantly fed from the top into the integrated reaction cabinet for hydration and carbonation with remaining heat and CO_2 in the industrial exhaust gas.

4) The finished cold-cured pellets constantly output from the bottom of the integrated reaction cabinet are dry and warm. Granules and crumbs of 6mm or below are eliminated through screening, and the remaining pellets of 6mm or above are constantly conveyed to the material warehouse of a steel-making plant or an iron-making furnace, or a special finished product warehouse for future use.

5) The whole production of the cold-cured pellets is of industrial scale and constant in a cool state without any pollution.

2. The iron concentrate described in Article 1 may have a normal grade of TFe 60-68%, or may be mixture of iron ore with grade of TFe<60% and iron concentrate with grade of TFe>60%, or may be the mixture of sheet iron, steel-making dust, dust containing iron, float red slurry that is hard to agglomerate, as well as other iron crumbs and iron concentrate.

3. The non-coking coal described in Article 1 is either blind coal or semicoke, or their mixture, or coke crumbs, coke dust or other substances containing coal.

4. The cement clinker described in Article 1 has a MgO content of $MgO \ngtr 5\%$ (proportion of MgO in cement clinker in weight).

5. The industrial exhaust gas described in Article 1 maintains a temperature of 120-300℃ and a CO_2 content of 20% or above (weight). It may be exhaust gas produced from the hot wind furnace of an iron-making plant, or the heating furnace of a rolling mill, or a sintering plant. It may also be the flue gas produced from a thermal power plant, or exhaust gas from limekiln or dolomite kiln, or exhaust gas from other coal furnace.

6. The integrated reaction cabinet described in Article 1 is a vertical tank made of steel structure or RC. The raw pellets enter from the top of the cabinet, and the finished pellets come out from the bottom of the cabinet. The industrial exhaust gas enters from the bottom of the cabinet, and is discharged from the top of the cabinet. Inside the cabinet, the cold-cured pellets experience the following chemical reactions:

Hydration: $C_3S\ (C_2S) \xrightarrow{\text{water}} C\text{-}S\text{-}H+nCa(OH)_2$

Carbonation: $Ca(OH)_2+CO_2+nH_2O=CaCO_3+(n+1)H_2O$

Statement

An industrial production method of cold-cured pellet used directly for iron and steel smelting

This invention is for constant industrial production of cold-cured pellets for steel and iron making. It belongs to iron and steel making field.

As for the existing technologies, the production of cold-cured pellets is non-constant and of small scale, which makes it hard to meet the demand of current iron and steel making industry for large scale and constancy. For instance, American Pellet Technology Company produces PTC cold-cured pellets in autoclave by steaming, and its production capability per line hardly exceeds 80,000t/y. It took Lisakov Mining and Dressing Company of former Soviet Union several months to produce 157.500t cold-cured pellets with autoclaves by steaming, and the pellets became powder by 1.3-51.9% (5mm or below) when delivered to Qaraghandy Iron & Steel Company for smelting test. The smelting performance was unstable, and the smelting test in blast furnace was seriously affected. The alkali metallic acid pellets of water glass type must be dried, and its production capability is only 50,000t/y per line. In Sweden, the pellet production capability reaches 1.6 million tons per year, but the production is not constant. The pellets shall be kept in the hardening warehouse for one week; then they are screened to sort out iron concentrate powder; and then they are kept outside the warehouse for three weeks to get the needed strength. As a result, a large amount of capital is tied up. Before this invention, the "cold-cured pellets directly for iron and steel making" were also produce non-constantly. When the raw pellets roll into finished pellets, they are air-dried in an open place, and then collected for use or put into a tank for

cultivation with 250°C industrial exhaust gas.

Another weak point of the cold-cured pellets produced with the existing technologies is low hot strength, which seriously limits its application. For instance, the connecting bond of Swedish pellets is damaged at about 600°C; the finished pellet rate is low; the availability for use in blast furnace is hard to exceed 40%. The hot strength of pellets of water glass type is poor, and only 20% is available for use in blast furnace; when the pellets are used for smelting, the availability coefficient shall be reduced by 3%. The Before this invention, the hot strength of "cold-cured pellets directly for iron and steel making" was also poor, and the availability for use in blast furnace was 65%. When they were directly used for steel making, the structural solidification rate of "minisized blast furnace" was low, and the metallic yield was ≤84%.

This invention is made just to kill the above-mentioned weak point.

Below is the illustration of this invention with the attached drawing.

This invention uses iron concentrate (1), non-coking coal (2) and cement clinker as raw materials, which are mixed in the blending column (4). Then, 5-10% water is added to plate pelletizer (5) or column pelletizer for production of pellets by rolling.

Iron concentrate: 64-77% (weight)	granularity: -200 mesh	accounting for 65%
Non-coking coal: 13-24% (weight)	granularity: 0.3mm or below	accounting for 95%
Cement clinker: 10-18% (weight)	granularity: 12μm or below	accounting for 90%

The summation of the above-mentioned components is 100% (weight).

The pellet contains 11-20% fixed carbon (weight).

The iron concentrate (1) may have a normal grade of TFe 60-80%, or may be mixture of iron ore with grade of TFe<60% and iron concentrate with grade of TFe>60%, or may be the mixture of sheet iron, steel-making dust, dust containing iron, float red slurry that is hard to agglomerate, as well as other iron crumbs and iron concentrate.

The non-coking coal (2) may be either blind coal or semicoke, or their mixture, or coke crumbs, coke dust or other substances containing coal.

The cement clinker (3) has a MgO content of MgO≯5%.

This invention adopts constant, volume and industrial scale production technology, and meets the

actual demand of modern iron- and steel-making furnaces.

The raw pellets (6) produced by rolling, when moist, constantly pass through the rolling screen (7) to achieve the specified granularity of 6-16mm. The raw pellets maintain smooth surface and don't stick to each other. They have sufficient capillary adhesive force and quick gelatification force of cement clinker. The raw pellets also have high strength and can bear 0.5kg compression. They don't break when falling from the belt with underlined iron plate, which is 460mm high. The strength meets the requirement for repeated transport during production.

The raw pellets (6) sorted out without any crumb, when moist, constantly enter the top of the reaction cabinet (8), which is a vertical steel structure or RC tank. Under the action of the industrial exhaust gas with a temperature of 120-300℃, cold-cured pellets are constantly hydrated and carbonated from the top to the bottom of the cabinet, so that most components of the cement clinker maintain certain temperature and moisture. The hydration of the cold-cured pellets is continued and accelerated, and a connecting bonds network forms inside the cold-cured pellets quickly, thus improving their intensity. Meanwhile, in the conditions of the temperature and moisture, carbonation takes place between the CO_2 in the industrial exhaust gas and the hydrates of C_3S and C_2S in the cement clinker, further enhancing the intensity of the pellets:

Hydration: $C_3S\ (C_2S) \xrightarrow{\text{water}} C\text{-}S\text{-}H + nCa(OH)_2$

Carbonation: $Ca(OH)_2 + CO_2 + nH_2O = CaCO_3 + (n+1)H_2O$

The industrial exhaust gas (9) mentioned above maintains a temperature of 120-300℃ and a CO_2 content of 20% or above (weight). It may be exhaust gas produced from the hot blast furnace of an iron-making plant, or the heating furnace of a rolling mill, or a sintering plant. It may also be the flue gas produced from a thermal power plant, or exhaust gas from limekiln or dolomite kiln, or exhaust gas from other coal furnace.

Since the above-mentioned industrial exhaust gas (9) enters from the bottom of the integrated reaction cabinet (8) to take part in the reaction, it can also dry the pellets, so that the cold-cured pellets can be carbonated and dried at the same time. Thus, the finished cold-cured pellets (10) can have a high intensity and be dry and warm as well to prevent frosting in winter.

After hydration and carbonation, the finished cold-cured pellets (10) constantly come out from the bottom of the integrated reaction cabinet (8), pass through the screen (11) to eliminate the granules and crumbs (12) of 6mm or below (accounting for 5%), and are constantly conveyed to the material warehouse of a steel-making plant or an iron-making furnace, or a special finished product warehouse for future use. Granules and crumbs (12) of 6mm or below are ground on the base of a roller (13), together with the moist granules (14) of 6mm or below sorted out by the screen, return to the deoxidization cabinet (15), are mixed by the mixer (4), and are made into pellets with water directly in the plate pelletizer (5).

In the above-mentioned process flow, the transport can be simplified and middle loss reduced. It is suitable for production control and reconstruction of an old enterprise.

This invention radically resolves the issue of poor hot strength of cold-cured pellets produced with the existing technologies. Below are the details:

1. The deoxidization drum indices of the cold-cured pellets of this invention are much better than those of the foreign quality roasted pellets and cold-cured pellets as well.

1) The deoxidization drum index of the cold-cured pellets of this invention at 500℃: RDI+6.3mm%=94.7%

2) The deoxidization drum index of the cold-cured pellets of this invention at 700℃: RDI+6.3mm%=72.0%

3) The deoxidization drum index of the cold-cured pellets of this invention at 900℃: RDI+6.3mm%=88.0%

2. The deoxidization expansion performance of the cold-cured pellets of this invention is much better than that of the foreign quality roasted pellets and agglomerated pellets as well.

According to the relevant national standard, the deoxidization expansion rate of the cold-cured pellets of this invention is RSI=2.1%.

3. The softening performance and melting performance of the cold-cured pellets of this invention under load are excellent, and the air permeability of the material column is better than that of the foreign quality baked pellets.

Test conditions: load of $0.5kg/cm_2$, 115g 6.3-10mm pellets (recovered at 900℃), Φ48mm pot, height of sample 60mm, 15g coke both on the top and at the bottom of the sample, temperature rise curve 10℃/min when <1100℃ and 5℃/min when >1100℃.

Test results:

Softening performance			Melting performance			ΔPmax
T10%	T40%	ΔT	Ts	Tm	ΔTms	5880Pa
1260℃	1345℃	85℃	1380℃	1418℃	38℃	

Note: T10% is the temperature at which the pellets distort by 10%; T40% is the temperature at which the pellets distort by 40%; Ts is the temperature at which the differential pressure rises abruptly; Tm is the temperature when melting takes place. △Pmax is the maximum differential pressure between the top and the bottom of the material column.

The above-mentioned advantage of the cold-cured pellets of this invention in hot strength is because the composition of the cold-cured pellets, the internal structure of the pellets, and the constant industrial production process jointly improve the hydration and carbonation with industrial exhaust gas. Under the actual operational conditions of a modern blast furnace, the internal pressure is approximately 0.12-0.35Mpa. Therefore, the networked $CaCO_3$ inside the cold-cured pellets of this invention after carbonation is decomposed at 910-960℃, so the pellets can maintain high hot strength before below 900℃. When it is 900℃, the cold-cured pellets of this invention has 11%-20% fixed carbon inside, which has deoxidization with ferric oxide to produce sticky phase that restricts the growth of acerate metallic iron crystal, and substitutes for the intensity system of the networked $CaCO_3$, so that the pellets continue to maintain extremely high hot strength till melting.

The features of this invention include:

1. The cold-cured pellets of this invention have unique internal structure – "minisized blast furnace" structure, which is the major reason that it can be used for direct steel making. Only this structure can "separate" "deoxidization" and "oxidization" in the steel-making furnace, which are opposite to each other. This invention adopts constant and mass production process, further improves the hot strength of the cold-cured pellets, makes the "minisized blast furnace" structure firmer, assures the reliability of the direct steel making technology of modern steel making furnace, and achieves the metallic acquisition rate of 84% or above.

In the structure of the cold-cured pellets of this invention, the cement clinker maintains a CaO content of 60% or above, which is a remarkable agent for deoxidization of ferric oxide. The coal powder, cement clinker and other materials necessary for deoxidization, melting and slagging of iron ores are delicately, evenly and closely blended with both the iron ores and pellets for reaction. Further, the cold-cured pellets of this invention won't crack or become powder at high temperature, and keep in good condition before separation of slag and iron, thus forming a static "minisized blast furnace". As a result, the deoxidization of ferric oxide can be separated from the outside, just like in a blast furnace. When the pellets are in the high-temperature steel making furnace, the capillaries that form during production of the pellets result in a lot of vents on the surface of the "minisized blast furnace". The vents spray out gas during the reaction inside the pellets, to prevent the oxidizing gas from entering into the "minisized blast furnace", thus further "separating" "deoxidization" from "oxidization" inside the steel making furnace, and forming the so-called "minisized blast furnace".

When numerous cold-cured pellets of this invention are put into modern steel making furnaces, it is like that numerous "minisized blast furnaces" are put into the steel making furnace, to achieve deoxidization of ferric oxide quickly, and then swiftly enter the normal steel making process after the slag and iron are separated.

2. When the solid "minisized blast furnace" featured by the cold-cured pellets of the invention is applied in the modern blast furnace to smelt iron, it can greatly improve the kinetic conditions under which the iron ore carries out the deoxidization reaction with the carbon, and make the non-coking coal replace the coke more effectively to take part the reaction inside the furnace. The replacement rate of coal is ≥1. Therefore, the cold-cured pellets of the invention may greatly reduce the coke rate to improve the production rate.

3. The production costs of the cold-cured pellets of the invention are remarkably lower than that of the sintered ore, which may be explained as follows:

1) The financial expenses and depreciation expenses are low. (The basic construction investment of the invention is 1/3 of the sintering machine of the same size.)
2) Low costs of the processing. (The finished products rate of the cold-cured pellets of the invention is as high as 92%, which is 13% higher than that of the sintered ore. The energy consumption in the manufacturing process of the cold-cured pellets of the invention is 62kg standard coal lower than the sintered ore.)
3) Low costs of the raw materials. (The super fine industrial waste that is hard to be sintered may be applied, such as the dust and dirt of the converter, floatation dirt and dry-quenching coal powder.)

Based upon #2 and #3 feature as listed as above, the iron-making costs may be reduced to a large extent when the cold-cured pellets of the invention are applied.

4. With the constant, large batch industrially sized production processing of the invention, not only the cold-cured pellets may satisfy the actual demands of the modern steel-smelting furnace and modern blast furnace, but also the entire manufacturing processing is performed in the cold position, producing no pollution caused by combustion.

When compared with the traditional iron-making processing system in terms of the single item of deoxidization of the pollution caused by the agglomeration, its economic and environment efficiency are great. For example, the Capital Steel, a large-sized enterprise that may produce eight million of pig iron annually, may save 890,000 tons of fuel for sintering each year and may reduce the pollution by 5100 tons (including a deoxidization of 1900 tons of SO_2, 1500 tons of NO_2 and 1700 tons of dust and dirt) each year.

5. The invention may optimize several importance performance of the charging materials for iron-smelting.

1) The temperature when the cold-cured pellets begin to be softened increases remarkably; the distribution of the soft heat belt of the blast furnace is changed, which is conducive to the

direct motion of the blast furnace. It is of great significance to those enterprises that depend on the ores (The fluorine-contained ore in the Inner Mongolia and the ferrovanadium and washingtonite ore in the western parts of Sichuan Province) with rather lower softening temperature as the raw materials for iron-making.

2) The best grain level (9-16mm) of the finished cold-cured pellets to entry the furnace accounts for 92%, which may meet the requirements put forward by the modern blast furnace for the fine fodder.
3) The effective rank is high. It is because that in the cold-cured pellets there is not the ash produced in the sintering process neither the ash brought along by the circulative application of the sintered return ore. With the cold-cured pellets manufactured with the Qian'an iron refined powder of the Capital Steel, the effective quality reaches 64% after the influence caused by the internally contained fuel and CaO are deducted. When the cold-cured pellets manufactured by the cost-effective and hard-to-be-sintered powder ore from the South Africa are applied, the effective quality may reach 63% after the influence caused by the internally contained fuel and CaO are deducted.
4) Good deoxidization performance. Since it has the particular feature of internal deoxidization as well as the up to 19% interspace degree, the total deoxidization index may reach 88% at the temperature of 900°C.
5) Good anti-pulverization performance. Since there is neither the F_eO nor the liquid structure generated in the sintering processing, the heat intensity is high and the there is not the pulverization phenomena with the liquid storage.
6) Good self-fluxing and desulfurization performance. It is because that there inside the cold-cured pellets is the even distribution of cement clinker with high activity and CaO contents of more than 60%. At the same time, it is because that the internally configured coal has good fineness and is evenly distributed.
7) The cold-cured pellets of the invention may be used to directly smelt the iron in the cupola:

The cold-cured pellets may generate by smelting the qualified cast iron and steel-making pig iron directly in the cupola with the hot air temperature of 500°C or above. It is of great significance to those direct foundry enterprises with excellent economic efficiency. It may greatly reduce the costs of those enterprises that depend on the cupola to smelt iron in the long run.

The implementation of the invention is as follows:

1. Evenly mix 73.5% iron powder of the qualified TFe 63% with 13.5% anthracite and cement clinker. Then add 9% water and form the cold-cured pellets on the disc pelletizer, which are to be sifted to 6-16mm grains by the roll screen and then directly enter into the comprehensive reaction chamber to go through the hydration and carbonation processing. The temperature of the waste industrial flue gas reaches 180°C, the single pellet intensity of the cold-cured pellets reaches 1150-1500N, the dual alkalinity R_2=13, the deoxidization drum indices at the 500°C reaches up to 94.7%. The production is constant and the sifting effects are excellent. The 9-16mm grains of the

cold-cured pellets account for 92%. The cold-cured pellets are dry, the grains are neat and maintain the slightly remaining temperature.

When 100% said cold-cured pellets are put into the $90M^2$ blast furnace for ore-smelting, a deoxidization of coke rate 250kg/t iron may be saved compared to the original smelting by the sintered ores. When the mix of 50% above-mentioned cold-cured pellets and 50% sintered ores is put into the 18 M^2 blast furnace for ore-smelting, a deoxidization of 172kg coke rate may be saved compared to the former smelting when the sintered ores are applied. The blast furnace carries out the direct motion and there are no phenomena of collapse and floatation of fodder. The utilization coefficient of the blast furnace is improved by 5%.

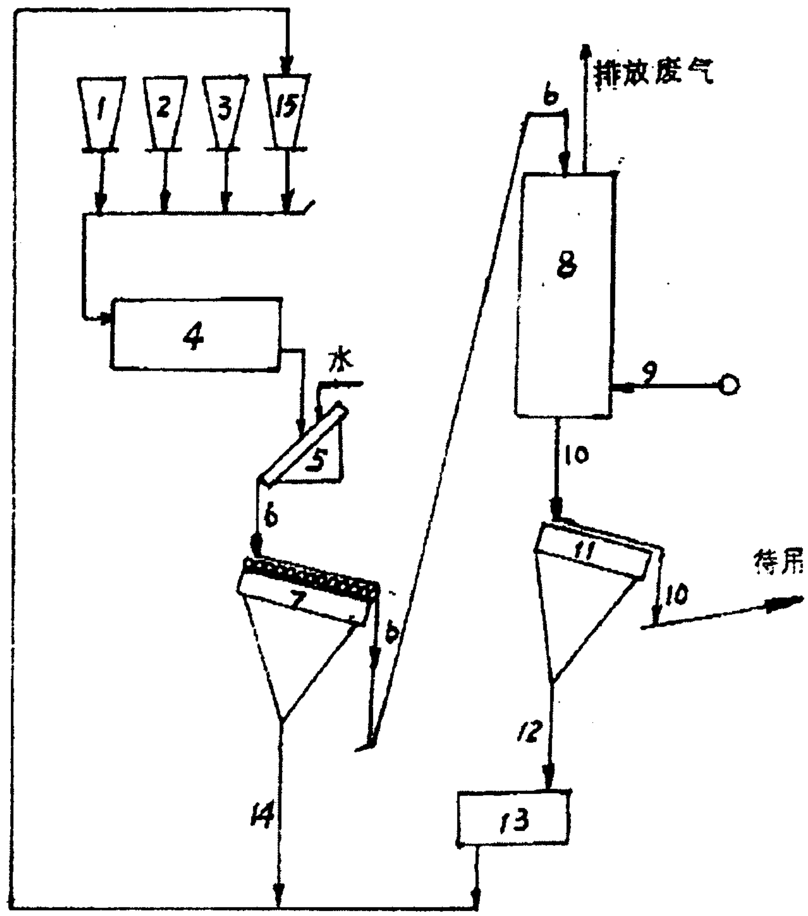
2. When the cold-cured pellets of the invention is smelted directly in the 150kg intermediate frequency steel-making furnace, the acquisition rate of metal is ≥84%. Before the desulfurization operation is performed for the molten steel, its contents are as follows:

C	Mn	Si	P	S
0.04	0.056	0.020	0.0043	0.187

3. When the cold-cured pellets of the invention are smelted in the cupola (The air temperature of 500℃) with a cubage of $13M^2$, the molten iron for the qualified cast pieces with the carbon contents of C=2.8-3.8% may be obtained directly. Compared to the cupola, it is featured by the low costs for production of cast iron pieces, good molten iron quality and lower contents of fluorine in the course of smelting (since one coke phosphatizating process is saved.)

Attachment of the specification

5. Water
6. Exhaust emission
10. To be used


排放废气
1
2
3
15
4
水
5
6
7
6
8
9
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11
待用
10
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14

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权利要求书 2 页 说明书 8 页 附图页数 1 页

[54]发明名称 一种直接炼钢和炼铁用冷固球团的工业生产方法

[57]摘要

本发明是一种工业规模连续生产直接炼钢和炼铁用冷固球团的方法，属于钢铁工业领域。

本发明用铁精矿、非焦煤和水泥熟料为原料，以低于烧结矿的投资和成本，连续大批量地生产直接炼钢和炼铁用冷固球团；并显著提高其热强度。

本发明使冷固球团的“微型高炉”结构更加牢固，增强了直接炼钢技术的可靠性；有利于高炉顺行，使非焦煤更有效地替代焦炭参加炉内反应，煤焦置换比＞1，从而大幅度降低炼铁焦比，提高生产率。

本发明的冷固球团可以在化铁炉中直接炼铁。

权 利 要 求 书

1、一种直接炼钢和炼铁用冷固球团的工业生产方法，其特征在于：

1) 冷固球团成份范围为：

铁精矿	64-77%(重量)	粒度-200目	占65%
非焦煤	13-24%(重量)	粒度0.3毫米以下	占95%
水泥熟料	10-18%(重量)	粒度12微米以下	占90%

以上组分总和为100%(重量)

2) 球团含固定碳11%－20%(重量)

3) 以上成份均匀混合后，在园盘造球机或园筒造球机中添加水5-10%，滚动造球。经滚动筛分成6-16mm表面光滑而互不粘结的生球，在湿润状态时，由综合反应仓上部连续进仓，用工业废烟气中的余热及所含CO_2进行球团的水化和碳酸化反应。

4) 由综合反应仓下部连续出仓的成品冷固球团干燥而略带余温，经连续筛分.筛去小于6mm以下的颗粒及碎屑后，通过有关皮带廊，连续地大批量直接进入炼钢厂料仓或炼铁高炉料仓或专用成品库待用。

5) 冷固球团的全部生产制造工艺，不但是工业规模、连续生产的；而且是冷态进行、无任何燃烧污染的。

2、根据权利要求1所述的铁精矿，正常品位为TFe60-68%，也可以是品位TFe<60%的铁矿石与品位TFe>60%铁精矿的混合物，也可以是轧钢铁皮、炼钢粉尘、含铁除尘灰，难以烧结的浮选红泥等工业含铁碎屑与铁精矿的混合物。

3、根据权利要求1所述的非焦煤是无烟煤、半焦煤或它们的混合物，也可以是焦屑、干熄焦细微粉尘或其他含碳物质。

权 利 要 求 书

4、根据权利要求1所述的水泥熟料，其氧化镁含量可以放宽到 MgO≯5%（氧化镁占水泥熟料重量的百分比）。

5、根据权利要求1所述的工业废烟气，温度120℃-300℃，CO_2含量在20%以上（重量），可以是炼铁厂热风炉燃烧后或轧钢厂加热炉燃烧后或烧结厂烧结过程产生的废烟气，也可以是火力发电厂的废烟道气，也可以是石灰窑或白云石窑的废烟或其他燃煤炉的废烟。

6、根据权利要求1所述的综合反应仓，是由钢结构或钢筋混凝土制作的立式大罐。生球由仓的上部进仓，成品冷固球团由仓的下部出仓。工业废烟气由仓的下部进入，通过仓的上部排放。仓内冷固球团进行如下化学反应：

水化反应式：$C_3S(C_2S) \xrightarrow{\text{水}} C-S-H + nCa(OH)_2$

碳酸化反应式：$Ca(OH)_2 + CO_2 + nH_2O = CaCO_3 + (n+1)H_2O$

说　明　书

一种直接炼钢和炼铁用冷固球团的工业生产方法

本发明是一种工业规模、连续生产直接炼钢和炼铁用冷固球团的方法，属于钢铁工业领域。

在现有技术中，各种冶金冷固球团的生产一直处于非连续的或小批量生产规模，难以满足现代钢铁工业大规模、连续性的需求和实际应用。例如：美国球团技术公司的PTC冷固球团，必须在高压釜中，一釜接一釜地蒸养成球，单线生产能力很难超过8万吨/年。前苏联里萨科夫采选公司用几个月的时间，才能造出157.500吨高压釜蒸养冷固球团，运到卡拉干达钢铁公司入炉冶炼试验时，因时隔数月，球团粉化现象严重，料车中5mm以下粉末量为1.3%－51.9%，冶金性能很不稳定，高炉冶炼试验受到严重影响。水玻璃系碱金属酸性球团，须经烘干工艺，单线生产能力只配置到5万吨/年。瑞典格兰亚斯球团的生产能力达到160万吨/年，但生产仍是非连续的，球团在硬化仓贮存一周后，筛出铺垫用的铁精粉后，还要转到仓外贮存三周后达到强度，资金占用相当严重。本发明前的“直接炼钢和炼铁用冷固结球团”也存在非连续生产的缺点：生球经滚动成球后，在广场上经过自然风干后收堆使用，或自然风干后再装入罐中，通过250℃工业废烟气进行养生后使用。

在现有技术中，各种冶金冷固球团的另一缺点是：热强度低，严重限制了它的实际使用。例如：瑞典球团的水硬性连接键在600℃左右，便遭到破坏；蒸养球团成品率低，粉化严重，高炉入炉率很难突破40%；水玻璃系球团的高温强度不足，入炉20%冶炼时，高炉利用系数要降低3%；本次发明前的“直接炼钢和炼铁用冷固结球团”热强度也存在不足，高炉入炉率也只达到65%。直接炼钢时“微型高炉”

结构巩固率较低，金属收得率≤84%。

本发明就是针对以上缺点而提出的。

结合说明书附图，说明如下：

本发明使用如下成份的铁精矿(1)、非焦煤(2)和水泥熟料(3)，经混料筒(4)均匀混合后，在园盘造球机(5)或园筒造球机中添水5-10%（重量），滚动成球。

铁精矿	64-77%(重量)	-200目	占65%
非焦煤	13-24%(重量)	0.3毫米以下	占95%
水泥熟料	10-18%(重量)	12微米以下	占90%

以上各组分总和为100%（重量）

球团含固定碳11-20%（重量）

其中铁精矿(1)的正常品位为TFe60-68%，也可以是品位TFe＜60%的铁矿石与品位TFe＞60%铁精矿的混合物，也可以是轧钢铁皮、炼钢粉尘、含铁除尘灰、难以烧结的浮选红泥等工业含铁碎屑与铁精矿的混合物。

非焦煤(2)是无烟煤、半焦煤或它们的混合物，也可以是焦屑、干熄焦细微粉尘或其他含碳物质。

水泥熟料(3)的氧化镁含量可以放宽到$MgO \ngtr 5\%$

本发明采用了以下连续、大批量、工业规模化的生产工艺，可以满足现代炼钢炉和现代炼铁炉的实际需要：

经过滚动成球的上述生球(6)，当其正处于湿润状态时，便连续经过滚动筛(7)筛分达到工艺规定的6-16mm粒度。这种生球表面光滑而互不粘结，具有充分的毛细粘结力和水泥熟料浆的快速胶凝力，生球强度很高，经得起0.5公斤施压而不碎裂，能从底衬铁板的皮带上面460mm高度处跌落8-14次而不碎，可以满足生产工艺过程中多次倒运的要求。

经过滚动筛分的不含碎屑的生球(6)，在湿润状态便连续地直接由综合反应仓(8)的上部入仓，综合反应仓(8)是由钢结构或钢筋混凝土制作的立式大罐，在温度120℃～300℃的工业废烟气(9)连续作用下，冷固球团由上而下连续实施水化与碳酸化工艺，使冷固球团内细磨水泥熟料中的大部分成份具有充分的温度和湿度条件，继续并加速水化反应，使冷固球团内部快速形成致密的网状连接键，提高了强度；同时在这种充分的温度和湿度条件下，工业废烟中的CO_2与水泥熟料中硅酸三钙(C_3S)和硅酸二钙(C_2S)的水化物中的网状$Ca(OH)_2$又能充分进行碳酸化，进一步增强了球团的强度：

水化反应式：$C_3S(C_2S)\xrightarrow{\text{水}}C-S-H+nCa(OH)_2$

碳酸化反应式：$Ca(OH)_2+CO_2+nH_2O=CaCO_3+(n+1)H_2O$

上述工业废烟气(9)的特征在于温度应在120℃～300℃，CO_2含量在20%以上（重量），可以是炼铁厂热风炉燃烧后或轧钢厂加热炉燃烧后或烧结厂烧结过程产生的废烟气，也可以是火力发电厂的废烟道气，也可以是石灰窑或白云石窑的废烟或其他燃煤炉的废烟。

由于上述工业废烟气(9)是从综合反应仓(8)下部进入而参加反应的，因而还有干燥球团的功能，使冷固球团的碳酸化失水与干燥过程同时进行，不但成品冷固球团(10)强度高，而且干燥略带余温，可以防止冬季结霜。

成品冷固球团(10)完成水化碳酸化工艺后，连续从综合反应仓(8)下部出仓，经过筛子(11)再次连续筛出工艺中挤压研磨后生成的小于6mm干燥颗粒及碎屑(12)后（筛余约重5%），即可连续地通过有关皮带廊，直接进入炼钢厂料仓或炼铁高炉料仓或专用成品库待用。小于6mm的干燥颗粒及碎屑(12)经碾盘(13)碾碎后，连同滚筛筛余的小于6mm的湿润颗粒(14)一起进入返矿仓(15)，通过混料机(4)混料后，直接在园盘造球机(5)中添水循环造球。

以上工艺流程可简化运输环节，减少中间损失，便于生产调度和

老企业改造。

本发明从根本上解决了现有技术中的各种冷固球团热强度不足的难题。表现在：

1、本发明的冷固球团，各阶段的还原转鼓指数都远远好于国外各种优质焙烧球团和冷固球团：

1) 本发明冷固球团的500℃还原转鼓指数:RDI+6.3mm%=94.7%

2) 本发明冷固球团的700℃还原转鼓指数:RDI+6.3mm%=72.0%

3) 本发明冷固球团的900℃还原转鼓指数:RDI+6.3mm%=88.0%

2、本发明的冷固球团还原膨胀性能远远好于国外优质焙烧球团和烧结矿：

参照国家标准测定：本发明的冷固球团的还原膨胀率RSI＝2.1%

3、本发明的冷固球团荷重条件下的软化特性，熔滴特性非常好，料柱透气性能优于国外优质焙烧球团矿。

测定条件如下：荷重0.5kg/cm²，6.3～10mm粒级球团115克，(球团经过900℃予还原)，装在直径48mm坩锅中，试样高度为60mm，试样上下各置入15克焦炭。升温曲线在＜1100℃时，10℃/分。＞1100℃时，5℃/分。

测定结果如下：

软化特性			熔滴特性			ΔPmax
T10%	T40%	ΔT	Ts	Tm	ΔTms	5880Pa
1260℃	1345℃	85℃	1380℃	1418℃	38℃	

注:T10%为球团变形10%时的温度,T40%为球团变形40%时的温度

Ts为压差陡升时的温度，Tm为熔滴时的温度。

ΔPmax为料柱上下两端的最大压差。

上述热强度优势是由本发明的冷固球团成份组成、球团内在结构

及其采用连续性的工业化生产工艺，提高了用工业废烟气进行水化与碳酸化综合反应效果而决定的。在现代高炉的实际操作条件下炉内压力约为0.12～0.35Mpa，此时，本发明的冷固球团内部碳酸化后的网状$CaCO_3$的分解温度为910～960℃，能确保900℃前球团保持较高的热强度。而在900℃ 时，本发明的冷固球团由于内部含有11%～20%的固定碳，与氧化铁进行还原反应而产生易粘结相，不但抑制了针状金属铁结晶的生长，还适时接替了网状$CaCO_3$的强度系统，使球团继续保持极高的热强度优势，直到熔滴。

本发明的特点是：

1、本发明的冷固球团具有独特的内在结构 ——“微型高炉”结构，这是实现直接炼钢的主要原因,只有这种结构,才能解决“还原”与“氧化”两个对立的反应能在同一炼钢炉中“隔开”，并依次完成的难题。本发明采用的连续、大批量工业规模的生产工艺，进一步提高了冷固球团的热强度，使“微型高炉”结构更加牢固，确保了现代炼钢炉采用直接炼钢技术的可靠性，金属所得率≥84%。

在本发明的冷固球团结构中，水泥熟料中CaO含量60%以上，是氧化铁还原良好的造渣剂。铁矿石还原、熔化、造渣所必须的煤粉、水泥熟料等材料细微、均匀而紧密地与铁矿石混合在球团之中进行反应。同时，本发明的冷固球团能确保在高温条件下不爆裂、不粉化，渣铁分离前始终保持完整性，这样就构成静态的“微型高炉”。使氧化铁的还原如同在高炉中一样，能与外界“隔开”。当球团处于炼钢炉中的高温状态时，由于球团成球过程的毛细管结构，使“微型高炉”表面存在某些可以透气的缺口，这些缺口在球团内部的反应过程中，能使周围形成不断向外喷出气体的小范围的气圈，能阻止炼钢炉中的氧化性气体向“微型高炉”内部扩散，进一步保持了球团内部“还原”与炼钢炉“氧化”气氛的“隔开”，构成动态的“微型高炉”。

因而，用无数个本发明的冷固球团投入现代炼钢炉冶炼时，就等于将无数个“微型高炉”投入炼钢炉内，先快速完成氧化铁的还原，

继而在渣铁分离后，迅速进入正常的炼钢过程。

2、本发明冷固球团所具有的牢固的“微型高炉”特征，应用在现代高炉炼铁时，能极大地改善铁矿石与碳素进行还原反应的动力学条件，使球团内的非焦煤，更有效替代焦炭参加炉内反应，煤焦置换比≥1。因而用本发明的冷固球团炼铁，能大幅度降低焦比，提高生产率。

3、本发明的冷固球团生产成本显著低于烧结矿。这是因为：

1)财务费用及折旧费用低。（本发明的基建投资是同规模烧结机的1/3）。

2)工序成本低。（本发明的冷固球团成品率高达92%，比烧结矿高13个百分点。本发明的冷固球团制造工序能耗比烧结矿低62公斤标准煤）。

3)原料成本低。（可以利用难以烧结的超细工业废料，例如转炉尘泥、浮选红泥和干熄焦粉尘等）。

综合上述第2条和第3条特点，应用本发明的冷固球团炼铁，能大幅度降低炼铁成本。

4、应用本发明的连续、大批量工业规模的生产工艺，不但使冷固球团可以满足现代炼钢炉和现代高炉的实际需要；而且全部制造工艺流程冷态进行，无任何燃烧污染。

单是减少传统炼铁工艺系统中烧结污染一项，其经济效益和环保效益就十分巨大。例如首钢这样规模的年产800万吨生铁的企业，每年即可减少烧结用燃料89万吨，每年减少排污量5100吨（其中减少$SO_2$1900吨，$NO_2$1500吨，灰尘1700吨）。

5、本发明可以优化炼铁炉料的若干重要性能：

1)球团开始软化的温度明显提高，改善了高炉软熔带的分布，有利于高炉顺行。这对于某些依赖软化温度较低的铁矿（内蒙的含氟铁矿，川西的钒钛铁矿等）作为炼铁原料的企业很重要。

2) 成品球团的入炉最佳粒级(9-16mm)占到92%，可满足现代高炉对精料的要求。

3) 有效品位高。这是因为球团中没有烧结过程产生的灰分及烧结返矿循环使用带来的灰分。用首钢迁安铁精粉制造的球团，扣除内含燃料及CaO的影响，有效品位高达64%。用价格低廉又难以烧结的南非粉矿配制的球团，扣除内含燃料及CaO的影响，有效品位可以达到63%。

4) 还原性能好。由于具有内还原特性和高达19%以上的孔隙度，900℃时的总还原指数可以达到88%。

5) 抗粉化性能好。由于不存在烧结过程产生的FeO和液相结构，不但热强度高，冷态贮放也没有粉化现象。

6) 自熔性好，脱硫性好。这是因为在球团内部均匀存在活性很高CaO含量60%以上的水泥熟料，同时内配煤粉细度好，分布均匀的缘故。

6、本发明的冷固球团，可以在10%～100%范围内，以任何比例与烧结矿匹配入炉炼铁，增加了生产调度的动态平衡手段，对现有企业的技术改造很有利。

7、本发明的冷固球团可以在化铁炉中直接炼铁：

在具有热风温度500℃以上的冲天炉中，本发明的冷固球团可以直接冶炼出合格的铸造用铁和炼钢生铁。这对于发展经济效益很好的直接铸造企业具有重要意义。对于长期依赖化铁炉进行化铁炼钢的企业，也可以大幅度降低成本。

本发明实施例如下：

1、将品位TFe63%的铁精粉73.5%，配以无烟煤13.5%及水泥熟料13%，均匀混合后，再添加水9%，在园盘造球机成球，经滚筛筛分成6-16mm粒度后，直接进入综合反应仓内水化及碳酸化，工业废烟气温度180℃，球团单球强度达到1150-1500N，二元碱度$R_2=1.3$，500℃还原转鼓指数达到94.7%，生产连续且筛分良好，球团9-16mm

粒级占92%，球团干燥、颗粒整齐，略带余温。

用上述冷固球团100%在$90M^3$高炉入炉冶炼时，比原来使用烧结矿冶炼可以降低焦比250公斤/t铁。用上述冷固球团50%与50%烧结矿搭配在$18M^3$高炉入炉冶炼时，比原来使用烧结矿冶炼，可以降低焦比172公斤。高炉顺行，无崩料悬料现象，高炉利用系数提高5%。

2、用本发明的冷固球团，在容量150公斤中频炼钢炉中进行直接炼钢时，金属收得率≥84%。钢水未经脱硫操作时，其成份为(%)：

C	Mn	Si	P	S
0.04	0.056	0.020	0.0043	0.187

3、用本发明的冷固球团，在容积$13M^3$的冲天炉(风温500℃)入炉冶炼时，可直接炼出含碳量C=2.8－3.8%的合格铸件用铁水。其特点是铸铁件的生产成本很低，铁水质量较好，含硫量比冲天炉化铁时含量低（由于减少一次焦碳渗硫过程）。

说 明 书 附 图